DIGITAL COMPUTER NEWSLETTER

The purpose of this newsletter is to provide a medium for the interchange, among interested persons, of information concerning recent developments in various digital computer projects

OFFICE OF NAVAL RESEARCH · MATHEMATICAL SCIENCES DIVISION

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Whirlwind I

Since the middle of January the Whirlwind computer has been using a second bank of 16 storage tubes (Bank B) that operate at a density of 32 x 32 spots. Good reliability has been obtained from these 1024 new registers. As these new tubes become available they will also be installed in Bank A.

The over-all reliability of the computer continues to be high (about 90%). During 1951 preventive maintenance procedure led to the removal of 473 vacuum tubes (of about 6,000 in service) before failure had occurred. Only 22 vacuum-tube failures, 16 of which were from shorts or opens, interrupted the operation of the computer. Experience with crystal rectifiers also has shown an improvement. A comparison of total crystal failures during 1951 with those of 1950 shows a decrease of 124, or 0.5 percent per thousand hours. This decrease is noteworthy, as the 1950 failure rate was only 1 percent per thousand hours. The total number of component replacements during 1951, other than vacuum-tube and crystal replacements, was 47. The percentage of failures per thousand hours for these miscellaneous components was approximately 0.02, the same figure as for 1950.

To the paper-tape input system has been added an interim magnetic-tape system for which programs are being prepared. The tape reader uses 6 heads grouped into 3 pairs, the heads in each pair scanning duplicate channels in order to eliminate errors due to blemishes in the tape. On January 19, over half a million 16-digit registers were recorded and checked, during a period of three hours, without an error.

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The January 1952 Newsletter listed five general problems (as distinguished from special military work) which are being attacked using Whirlwind I. Other general problems being worked on, together with the department or agency that initiated them, are the following:

Torpedo depth response (Electrical Engineering)
Magnetic flux in ferritic media (Electrical Engineering)
Hydrothermal electric system (Electrical Engineering)
Intact stability studies (Bureau of Ships) (Elec. Eng.)
Auto- and Cross-correlation coefficients (Meteorology)
Oil-refining problems (Industrial)
Analyses of seismic data in oil location (Geology, Math.)
Analysis of noise (Mathematics)
Crystal structures (Chem., Electrical Engineering)
Aircraft gust loads (Aero. Engineering)
Internal combustion engines (Mech. Engineering)
Group-networks statistics (Economics)
Schroedinger wave equation (Physics, Electrical Eng.)
Shear walls (Civil Engineering).

In addition to the regular academic program in digital computers, M.I.T. will offer in July, 1952, a special intensive two-week summer session in Digital Computers and their Applications. Included in the course will be a survey of applications and logical structure as well as a detailed treatment of programming techniques, emphasizing the use of various kinds of subroutines in facilitating the preparation of and the location of mistakes in programs. The instruction will be by members of the M.I.T. Digital Computer Laboratory staff. The Whirlwind computer will be used to provide group demonstrations and individual practical experience.

The ONR Relay Computer

As a result of arrangements made by the Office of Naval Research, a general-purpose computing machine was permanently installed in Staughton Hall on the campus of The George Washington University on 9 May 1951. At that time it was renamed the ONR Relay Computer and was loaned for operation and maintenance to the Logistics Research Project which is under ONR contract at the University.

The machine is a low-speed relay computer with magnetic-drum storage of 4,094 numbers, each consisting of 24 binary digits (equivalent to about seven decimal digits). It is capable of performing 39 arithmetic, logical, transfer, and output commands through use of 734 mechanical relays and 655 electronic tubes. The multiplication time is 2-1/2 seconds. Input to the computer is by mechanically sensed, seven-level teletype tape, while output may be on punched tape or by electric typewriter. Control is of the single-address type. Tape preparation, duplication, and print-out (typewriter) equipment were also delivered with the computer.

Below are examples of programs which have been run during the past few months.

(1) At this writing, the Project is computing quarterly man-power requirements implied by a proposed shipbuilding schedule. Given the building dates and total manpower requirement of a ship, a fourth-degree polynomial is evaluated to distribute the man-hour requirements into yearly quarters. These requirements are summed for the fleet.

(2) A calculation was done for the Air Force determining the amount of fuel required in an operations area. Data included the number of each type of plane in the area, the expected flying hours, and figures for fuel consumption per hour.

(3) The computer has been used for the preparation of input tapes of Marine Corps allowance lists for the Logistics Computer, a special-purpose electronic computer being built for ONR by Engineering Research Associates, Inc. It will be delivered late in 1952 for operation by the Logistics Research Project.

(4) A program was prepared for the iterative solution of games by Brown's method, each player having as many as 20 strategies. Several hours were spent on the computer solving a sample game.

The ABC

The Automatic Binary Computer (ABC) of the Air Defense Office of the Air Force Cambridge Research Center, 230 Albany Street, Cambridge 39, Massachusetts, is a general-purpose four-address machine with serial magnetic-drum memory and parallel arithmetic unit. Drum capacity is 4,096 fifty-six-bit words.

Data are handled internally in pure binary form, with provision for the computer to convert input data from decimal to binary and output data from binary to decimal. Alternatively, data can be inserted and removed in octal form.

Initially, input-output will be by electric typewriter, with tape input-output projected for the future.

The medium-speed arithmetic unit will multiply two fifty-six-bit numbers in 1,200 microseconds.

The present drum system, with average access time of 10 microseconds, is the limiting factor of over-all computer speed; it was used because it was immediately available. This access time will be greatly reduced in practice by coding techniques.

The logical design of ABC is complete; construction and trouble-shooting are in progress.

The SEAC

In December 1951 an additional control unit, for operation of SEAC in the three-address mode, was built and is being installed. It features a counter to generate the address of subsequent instructions in a subroutine and has provisions for resetting the counter to any arbitrary memory position at the end of a subroutine. This means that a subroutine may be coded without reference to actual positions in the memory in which it is stored, and therefore the same subroutine may be used in one part of the memory for one problem and in another part of the memory for another problem with only minor modifications. It is anticipated that this feature will aid in the utilization of a library of subroutines and thus increase the usefulness of SEAC by reducing the time of problem-solving.

The Williams memory is now in regular operation with 512 spots. It is scheduled for approximately 40 hours of operation per week and has been utilized for nearly 500 hours of useful computation. Its reliability is now better than that of the acoustic memory when SEAC was first put in operation a year and a half ago but is not as good as the current acoustic system. The most valuable use of the Williams memory has been on large problems for which the unchanged constants and instructions are stored in the Williams memory and all variable factors and results are stored in the acoustic memory. The information stored in the Williams memory is checked periodically by comparing its sum with a previous sum of the constant terms to detect possible error. The combined use of the two memories has proved both fast and effective.

The SWAC

The lowering of the accelerating voltage on the Williams-tube memory system was reported in the last _Newsletter_. The installation of a delay system to minimize difficulties with respect to read-around ratio, and the installation of the motor generator set to stabilize voltages and minimize adjustments, have paid off in an increase in operating time on the SWAC.

The electrostatic memory still predominately uses 5JP-type tubes with their high incidence of flaws, but with these tubes it is possible to operate regularly with read-around ratios of 40 to 1, and only a few units fail to operate at approximately 100 to 1. Two 3-inch tubes made under the BuShips contract at RCA have been in use during the last quarter with very good results.

Continuing effort is being expended on improvements of the present Williams-tube memory.

During this quarter two new Mersenne primes, $(2^{521} - 1)$ and $(2^{607} - 1)$, were discovered by the SWAC.

The Circle Computer

Specifications for the standard production models of this machine (Newsletter for October 1951) are now fairly complete, and sales price and delivery time have been established by the manufacturer (Hogan Laboratories, 155 Perry Street, New York 14, New York).

Moore School Automatic Computer (MSAC)

The construction of the Dispatcher Memory Loop of the MSAC has been completed. It has undergone static and dynamic tests and has succeeded in performing all its logical functions. This unit was built and tested under an interim program established for the purpose of obtaining final performance information on the basic circuits in order to make any modifications of the circuitry that may be necessary. In addition, the time required in the construction and testing of this unit will give an accurate indication of the time required to complete and test the entire machine. An interim power supply, combining an electronically regulated Thyratron supply and a storage-battery supply, has been completed, together with an automatic charging unit, to keep the battery voltages within design tolerances.

Work is continuing on the drawing of schematics and the procurement of parts.

The UNIVAC

Acceptance tests have been passed on the second UNIVAC system, and it is in the process of being installed for the Office of the Air Comptroller. The third UNIVAC system is rapidly nearing completion and should be ready for acceptance tests very shortly.

The Jacobs Instrument Company Computers (JAINCOMP)

The JAINCOMP computers are all-parallel, electronic, asynchronous computers suitable for both control and computational applications. Work on these computers was started in the late spring of 1949. The first machine (JAINCOMP-A) was completed and tested in the early spring of 1950. This machine weighed 40 lbs. It had a wired-in automatic program involving addition, subtraction, multiplication, decision, and the taking of sines. It used punch-card storage for constants and flip-flop storage for intermediate values. It had one channel of variable (instrument) input to demonstrate its usefulness for real-time (control) applications.

The second Jacobs Instrument Company computer, (JAINCOMP-B), was started in the fall of 1950 and completed in the fall of 1951. This is a compact device (16-1/2 x 21-1/4 x 30 inches) weighing 110 lbs. It handles 24 binary digits and adds two 24-digit numbers in eight microseconds. It uses toggle-switch storage, of two microseconds access time, for constants which are changed from problem to problem. For high-speed storage it uses a very compact magnetic system having a maximum storage time of eight microseconds, and a maximum access time of four microseconds, for a 24-digit word. The machine has subcontrols for such processes as addition, subtraction, multiplication, division, finding sines and arc sines, and cubing. The original JAINCOMP-B machine had four wired-in programs, each involving solutions of two different algebraic equations. In February 1952 a flexible general-purpose programming system was added to the computer. This modified machine is called JAINCOMP-B1. Company representatives state that it has shown very great reliability. Also in February an ultracompact magnetic storage device was designed and tested.

A device for converting a shaft rotation to a binary computer input was developed in January 1951. Accuracies of a few seconds of arc appear obtainable with this type of device. Readings can be made at any desired rate up to about 200 per second and can be fed directly into a computer at these rates.

The CADAC

The CADAC was delivered to the Air Force Cambridge Research Center in January 1952. It is now located at the Massachusetts Institute of Technology on an indefinite loan. It was shipped to Cambridge by air and rail express and was placed in operation within two weeks after its arrival. It has been operated, as of February 16, over a two-week period. During this time only one machine error occurred while operating for an average of four hours per day for ten days.

For most of this period, the computer has been used in training the maintenance personnel who will be in charge of the machine and in accustoming the users to the techniques of programming.

The following problems have been solved on the computer:

(1) A decimal-to-octal and octal-to-decimal conversion.
(2) Solution of eight simultaneous linear equations.

Plans are under way for an improved version of the CADAC, making possible decimal input and output, with the computer doing its own conversion. A Flexo-Writer unit will replace the present keyboard and typewriter so that punched paper tape can be utilized as input for repeatable problems. In addition, an auxiliary storage magnetic-tape unit automatically controlled by the computer will replace the manual tape unit. Certain other design improvements will be made.

Computer Research Corporation is also building two other computers. One is a larger, faster, completely decimal general-purpose computer with a large amount of flexible input-output equipment. This machine, CRC 107, will handle business applications as well as scientific problems since it can accept and print alphabetic characters.

The second is a decimal digital differential analyzer primarily designed for utmost convenience to the user and with a complete set of printing, plotting, and empirical-function input-output equipment.

Consolidated Electronic Digital Computer Model 30-201

Consolidated Engineering Corporation, 300 N. Sierra Madre Villa, Pasadena 8, California, has under development a moderate-size general-purpose digital computer. The main memory is a magnetic drum with a capacity of 4,000 words. A quick-access memory is also provided with a total capacity of 80 words. Special commands are provided which accomplish the transfer of blocks of 20 words between the main memory and the quick-access memory. The computer employs a single address command system. The number length is eight decimal digits plus algebraic sign; fixed-point operation is normally employed. The binary-coded-decimal notation is employed.

In the design of the computer, reliability and ease of coding are emphasized. The power consumption will be less than 6 kva and the floor area occupied by the computer will be approximately 2 ft. by 8 ft.

A special feature, not ordinarily included in general-purpose computers of the intermediate-speed type, is the B-register. This register has been included to facilitate the coding of iterative operations. When a command is coded as a special command, the contents of this B-register are added to the address portion of the command before it is executed. Special provisions are made for increasing, decreasing, and changing the numbers stored in the B-register.

In many cases the computer may be supplied its input information (numbers) by automatic data-handling systems, such as Consolidated's SADIC and MILLISADIC analogue-to-digital conversion systems. If the computation program has been previously stored on the magnetic drum, the results of the computations can be obtained within seconds after the original measurements.

The ACE Pilot Model

The ACE Pilot Model has been designed and constructed by the Electronics Section, National Physical Laboratory, Teddington, England, in collaboration with members of the Mathematics Division and a number of engineers and technicians from the English Electric Company. Its main features are still as described in the December 1950 issue of the Newsletter, but the control system has been improved and an automatic multiplier added; also, new adjustable-length, reflection-type, mercury delay lines have been designed and constructed and will replace the existing straight-through lines.

This machine was built solely to gain experience before designing the ACE itself and is therefore very inadequately furnished with check and maintenance facilities. It has proved, however, to be a very fast and efficient computing machine, and the immediate requirement for high-speed

computation is such that anything that can be made to work must be made use of. It will therefore be maintained in service while the ACE is being designed and constructed. In fact, a fully engineered version of it is now contemplated as the next step, since this could be produced in a relatively short time. Meanwhile, auxiliary magnetic-drum storage is being added to it to secure the necessary capacity for large-scale problems.

The ACE Pilot Model was designed for a 2-address code in order to simplify its construction, but the ACE itself will have, as originally intended, a 3-address code, with a consequent substantial gain in over-all computation speed; but there is not, at present, any intention to change to electrostatic storage. The acoustic delay-line storage as now designed is robust, reliable, and very insensitive to external disturbances. It is commonly assumed that its relatively long access time as compared with the Williams cathode-ray system is a serious disadvantage, but this has been largely obviated in the Pilot Model by a logical design which permits optimum programming. This is perhaps the most interesting feature of the machine.

An example of the gain in speed obtainable in this way is provided by the problem quoted in the <u>Newsletter</u> for April 1951. The demonstration that 99,999,999,977 is prime took SEAC 36 minutes using delay line storage and 12 minutes 8 seconds using the Williams C.R. storage. It was done on the ACE Pilot Model (which has the same pulse rate as SEAC and similar delay lines) in 7 minutes 45 seconds in spite of the facts that the shorter word length of this machine necessitated double-length arithmetic procedure and that the machine has very limited arithmetic facilities which do not include automatic division. The average rate at which the 2-address instructions are carried out in this problem is 13,000 per second.

Data-Handling Devices

Telecomputing Corporation, 133 East Santa Anita Avenue, Burbank, California, announces its new voltage-to-digit converter known as the Teleducer. The device consists of an electronic servo system providing an accuracy of one part in 127, with a minimum useful input of one volt full scale and output in binary digital form. The Teleducer is completely electronic, and its binary scaling rate of 25 kc permits it to follow voltage variations equivalent to a 40-cps sine wave, never lagging by more than one count.

Another new development of Telecomputing Corporation is its magnetic reading head, which converts shaft rotation into digital form by directly (without gearing) dividing each revolution into as many as 10,000 counts. The magnetic reading head is a completely ac device, thus avoiding the usual problems of dc amplifier drift.

Teleplotters are currently being delivered at the rate of three a month, with six now in service. The Teleplotter will provide extremely accurate graphical output for a variety of types of digital computers, although thus far its use has been limited to punched-card and manual-keyboard input.

Comments, letters to the editor, and additional contributions for inclusion in the Newsletter should be addressed to:

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